

Status of $B^0 \rightarrow \rho^\pm h^\mp$ CP-analyses

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Status of $B^0 \rightarrow \rho^\pm h^\mp$ CP-analyses

- CP-results and signal yields were presented at ICHEP-2002 and we faced a choice of two publication options:
 - Option 1:** - proceed with quick PRL publication of everything we had
 - Option 2:** - invest more work into analyses and get the measurements of $Br(B^0 \rightarrow \rho^\pm \pi^\mp)$, $Br(B^0 \rightarrow \rho^\pm K^\mp)$

→ after consultations with colleagues, and with the blessing of Physics coordinator we decided to do it "hard way": **Option 2:**

Good and bad things about measurements of branching ratios

- for the extraction of CKM angle "alpha" the values of $Br(B^0 \rightarrow \rho^\pm \pi^\mp)$, $Br(B^0 \rightarrow \rho^\pm K^\mp)$ are as important as the values of CP-parameters
- RhoPi team was at peak of its form, with all the tools and machinery at place and we were afraid that as time goes by people would start to leave and it will takes years to get back to branching ratios
- we felt that for such complicated analysis, it's good to have some time for careful crosschecking, debugging
- BRs measurements are hard - need much better confidence in the background model than CP fit alone!

List of modifications and changes

- revisited and extended B-background simulation went from 80 to 110 modes, addressed the issue of missed $B \rightarrow K^{**} X$ where $K^{**} = K_0(1430)$, $K_2(1430)$, $K_0(1640)$
- cross-check measurements of $\text{Br}(\text{RhoPi})$, $\text{Br}(\text{RhoK})$, (using Cut&Count) and $\text{Br}(B \rightarrow K^{**} X)$ (full Likelihood)
- cross-checks of $b \rightarrow c$ inclusive rates from independent data samples for RhoPi , RhoK selections
- switch to *smeared* B-bkg MC samples (where pi0s are hard)
- switch to TracksLoose from TracksVeryLoose
- added 1999 and more 2002 data, bad runs filtering
- small bugs and improvements: bad Rho MC shapes,

New B-background modes with K_X^{**} and f_X

- some inclusive B to 3-body decay rates are known and can be used as constraints for $B \rightarrow K_X^{**}(K\pi)\pi$
And $B \rightarrow K f_x(\pi\pi)$ rates:

$$B(B^0 \rightarrow K^+ \pi^- \pi^0) = (37.4 \pm 12.0) \cdot 10^{-6} (\text{Belle})$$

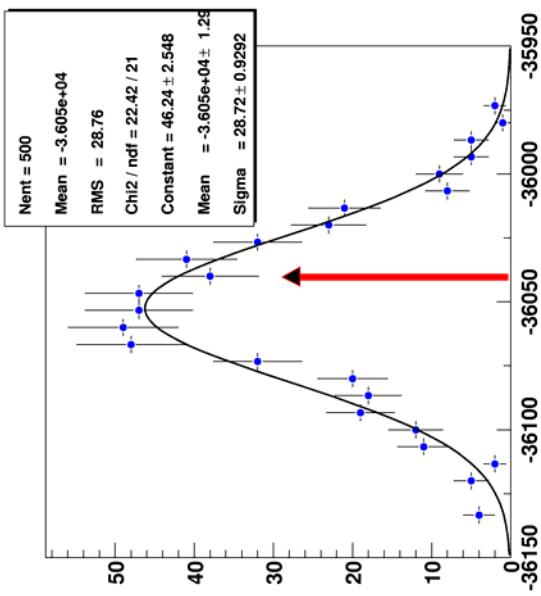
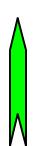
$$B(B^+ \rightarrow K^+ \pi^- \pi^+) = (53.9 \pm 15.0) \cdot 10^{-6} (\text{BaBar})$$

- obviously, there is a number of ways these types of backgrounds can contaminate the $B^0 \rightarrow \rho^\pm K^\mp$ decays via 3-body and 4-body final states

- to simulate $B \rightarrow K_X^{**}\pi$ we consider **1 : 1 : 1 mix** of $K_0(1430)$, $K_2(1430)$, $K(1680)$ resonances (see PDG)

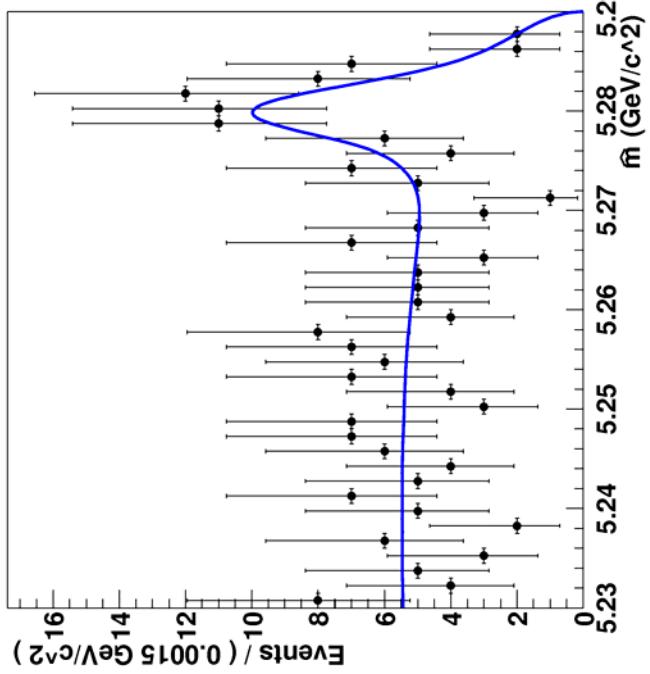
Measurements of $B \rightarrow K^* \pi$ branching ratio

likelihood fit is validated, Δm
and τ -lifetime fits are
consistent with PDG, high
CL of the fit to data:



$$Br(B^0 \rightarrow K^*(K^+\pi^0)\pi^-) = (4.2 \pm 0.8) \cdot 10^{-6}$$

consistent with Belle's number:
 $(8.7 \pm 3.0) \cdot 10^{-6}$



Measurements of $B \rightarrow K^{**} \pi$ rates

Table 54: Estimation of the $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$ branching fraction for various hypotheses of K_X^{**} components. The selection is optimized for the modes $K_0^*(1430)$ - $K_2^*(1430)$. The fit gives yields equal to 100.7 ± 16.7 .

K_X^{**} type	Efficiency (%) for $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$	Branching Fraction (10^{-6}) for $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$
$K_0^*(1430)$ (100%)	8.3	13.8 ± 2.3
$K_2^*(1430)$ (100%)	12.0	9.5 ± 1.6
$K^*(1680)$ (100%)	4.5	25.6 ± 4.3
$K_0^*(1430)$ (50%) + $K_2^*(1430)$ (50%)	9.6	11.9 ± 2.0
$K_2^*(1430)$ (33.3%) + $K_2^*(1430)$ (33.3%) + $K^*(1680)$ (33.3%)	8.5	13.5 ± 2.2

Table 55: Estimation of the $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$ branching fraction for various hypotheses of K_X^{**} components. The selection is optimized for the mode $K^*(1680)$. The fit gives yields equal to 47.2 ± 12.2 .

K_X^{**} type	Efficiency (%) for $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$	Branching Fraction (10^{-6}) for $B^0 \rightarrow K_X^{**} \pi \rightarrow K^\pm \pi^\mp \pi^0$
$K_0^*(1430)$ (100%)	4.6	11.7 ± 3.0
$K_2^*(1430)$ (100%)	5.8	9.2 ± 2.4
$K^*(1680)$ (100%)	7.1	7.6 ± 2.0
$K_0^*(1430)$ (50%) + $K_2^*(1430)$ (50%)	5.0	10.7 ± 2.8
$K_2^*(1430)$ (33.3%) + $K_2^*(1430)$ (33.3%) + $K^*(1680)$ (33.3%)	5.5	9.8 ± 2.5

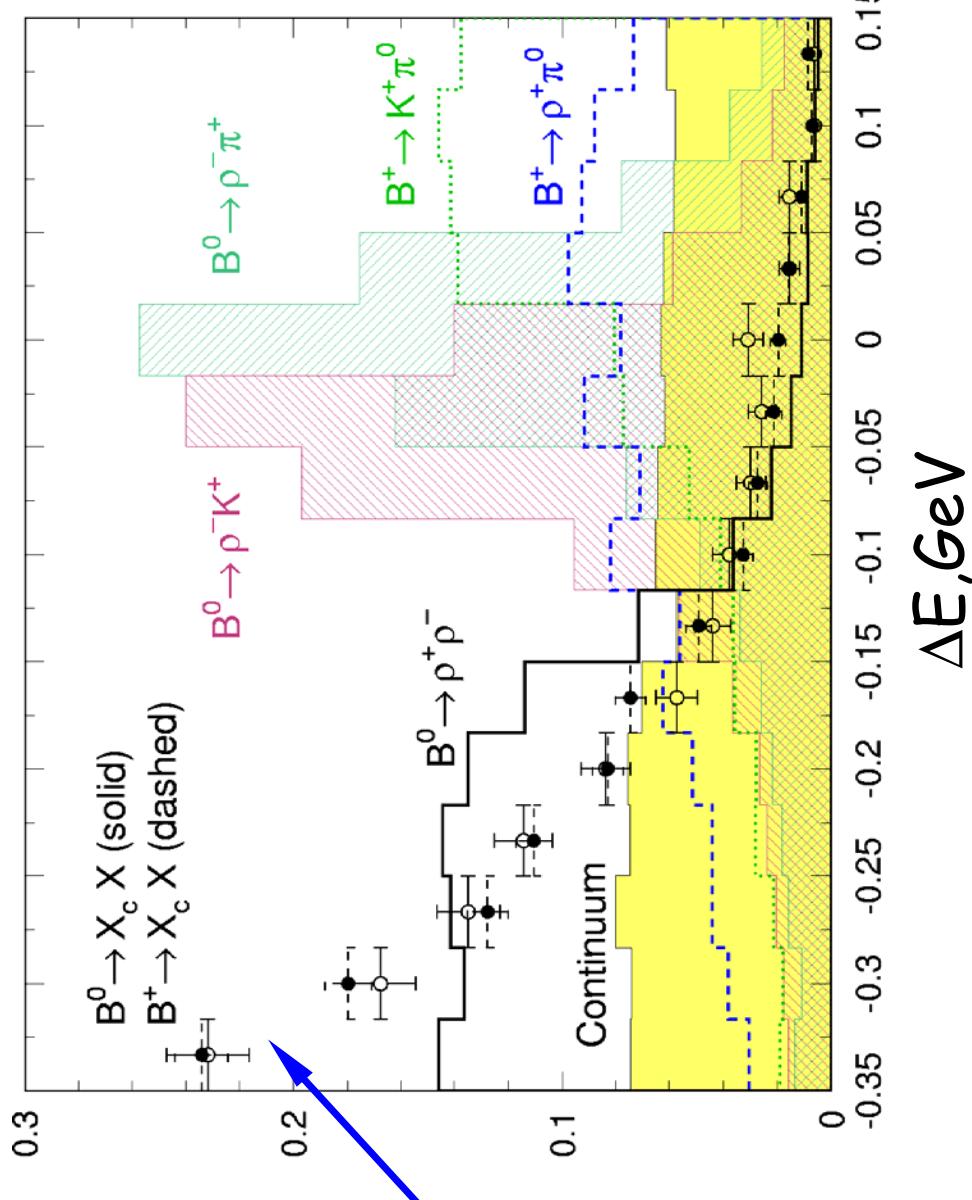
range used

New B-background modes with K_X^{**} and f_X

$B^+ \rightarrow K^+\pi^0$	12.7 ± 1.2	0.00	1.63	0.0 ± 0.0	18.2 ± 1.7	71	2
$B^+ \rightarrow \pi^+\pi_0^-$	5.8 ± 1.0	0.98	0.00	5.0 ± 0.9	0.0 ± 0.0	72	2
$B^+ \rightarrow \left\{ \begin{array}{l} K^+\rho^0 \\ \pi^+K^{*0}(\rightarrow K^+\pi^-) \end{array} \right.$	3.9 ± 3.0	0.26	2.99	0.9 ± 0.7	10.2 ± 7.8	53	1
$B^+ \rightarrow \left\{ \begin{array}{l} K^+\pi^+\pi^-_{[{\rm nonres}]} \\ (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	10.3 ± 2.6	0.04	0.00	0.4 ± 0.1	0.0 ± 0.0	47	-
$B^+ \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	0.0 ± 3.0	0.10	0.19	0.0 ± 0.3	0.0 ± 0.5	66	-
$B^+ \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	15.0 ± 8.0	0.36	0.05	4.7 ± 2.5	0.7 ± 0.4	-	10
$B^+ \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	13.0 ± 9.0	0.31	1.20	3.5 ± 2.4	13.7 ± 9.5	-	1
$B^+ \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	11.7 ± 4.0	0.16	1.40	1.6 ± 0.6	14.2 ± 4.8	57	1
$B^+ \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^+ \\ K^+f_X(1300) \\ K^+f_0(980) \end{array} \right. \rightarrow K^+\pi^-\pi^+$	53.9 ± 15.0	25 ± 25	0.21	0.03	4.7 ± 4.7	0.7 ± 0.7	-
$B^+ \rightarrow (K_X^{(**)}\pi)^+ \rightarrow \text{other than } K^+\pi^-\pi^+$	15 ± 15	0.06	0.06	0.8 ± 0.8	0.8 ± 0.8	-	12
$B^+ \rightarrow (K_X^{(**)}\rho)^+ \rightarrow K^+\pi^-\pi^+X$	4.0 ± 3.0	0.10	0.00	0.4 ± 0.3	0.0 ± 0.0	19	-
$B^+ \rightarrow K_S^0\rho^+$	5.0 ± 3.0	0.04	0.07	0.2 ± 0.1	0.3 ± 0.2	93	-
$B^+ \rightarrow K^{*+}(\rightarrow K^+\pi^0)f_0(980)$	4.4 ± 2.5	0.29	0.00	1.1 ± 0.6	0.0 ± 0.0	46	0
$B^+ \rightarrow \pi^+K^{*0}(\rightarrow K_S^0\pi^0)$	4.4 ± 2.5	0.00	1.55	0.0 ± 0.0	6.0 ± 3.4	95	1
$B^+ \rightarrow \pi^0K^{*+}(\rightarrow K^+\pi^0)$	8.7 ± 5.0	2.50	1.58	19.1 ± 11.0	12.1 ± 6.9	45	6
$B^+ \rightarrow \left\{ \begin{array}{l} \pi^0K^{*0}(\rightarrow K^+\pi^-) \\ K^+\pi^-\pi_0^-_{[{\rm nonres}]} \end{array} \right. \rightarrow K^+\pi^-\pi^0$	8.7 ± 5.0	0.01	1.51	0.1 ± 0.1	11.5 ± 6.6	48	5
$B^0 \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^0 \\ (K_X^{(**)}\rho)^0 \\ K^+\pi^-\pi_0^-_{[{\rm nonres}]} \end{array} \right. \rightarrow K^+\pi^-\pi^0$	0.0 ± 3.0	0.21	1.31	0.0 ± 0.6	0.0 ± 3.4	64	-
$B^0 \rightarrow \left\{ \begin{array}{l} (K_X^{(**)}\pi)^0 \\ (K_X^{(**)}\rho)^0 \\ K^+\pi^-\pi_0^-_{[{\rm nonres}]} \end{array} \right. \rightarrow K^+\pi^-\pi^0$	20.0 ± 15.0	0.00	1.08	0.0 ± 0.0	19.0 ± 14.3	-	9
$B^0 \rightarrow (K_X^{(**)}\pi)^0 \rightarrow \text{other than } K^+\pi^-\pi^0$	37.4 ± 12.0	52 ± 52	0.43	0.39	19.8 ± 19.8	17.6 ± 17.6	-
$B^0 \rightarrow (K_X^{(**)}\rho)^0 \rightarrow K^+\pi^-\pi^0 X$	20.0 ± 20.0	0.02	0.17	0.4 ± 0.4	2.9 ± 2.9	-	11
$B^0 \rightarrow K^{*0}(\rightarrow K^+\pi^-)f_0(980)$	10.0 ± 7.0	0.02	0.06	0.2 ± 0.1	0.6 ± 0.4	94	-
$B^0 \rightarrow \pi^-K^{*+}(\rightarrow K_S^0\pi^+)$	8.7 ± 5.0	0.35	0.00	2.6 ± 1.5	0.0 ± 0.0	44	3

Measurement of the inclusive $b \rightarrow$ charm rate

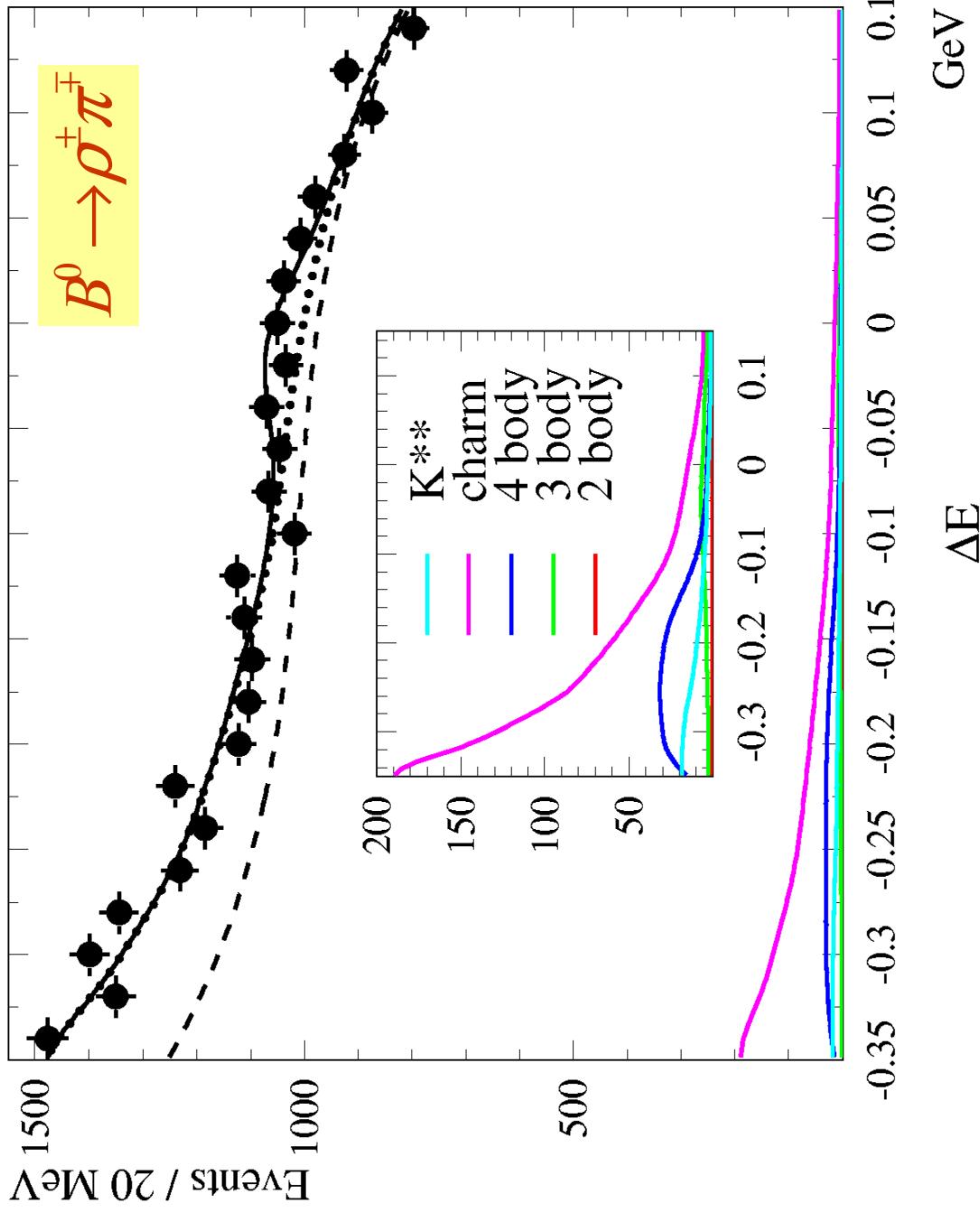
→ it's not clear how much confidence we should place upon the absolute number of $b \rightarrow$ charm events predicted by generic B SP4 Monte Carlo (we'd better check!)



sensitivity to $b \rightarrow$ charm grows at negative ΔE

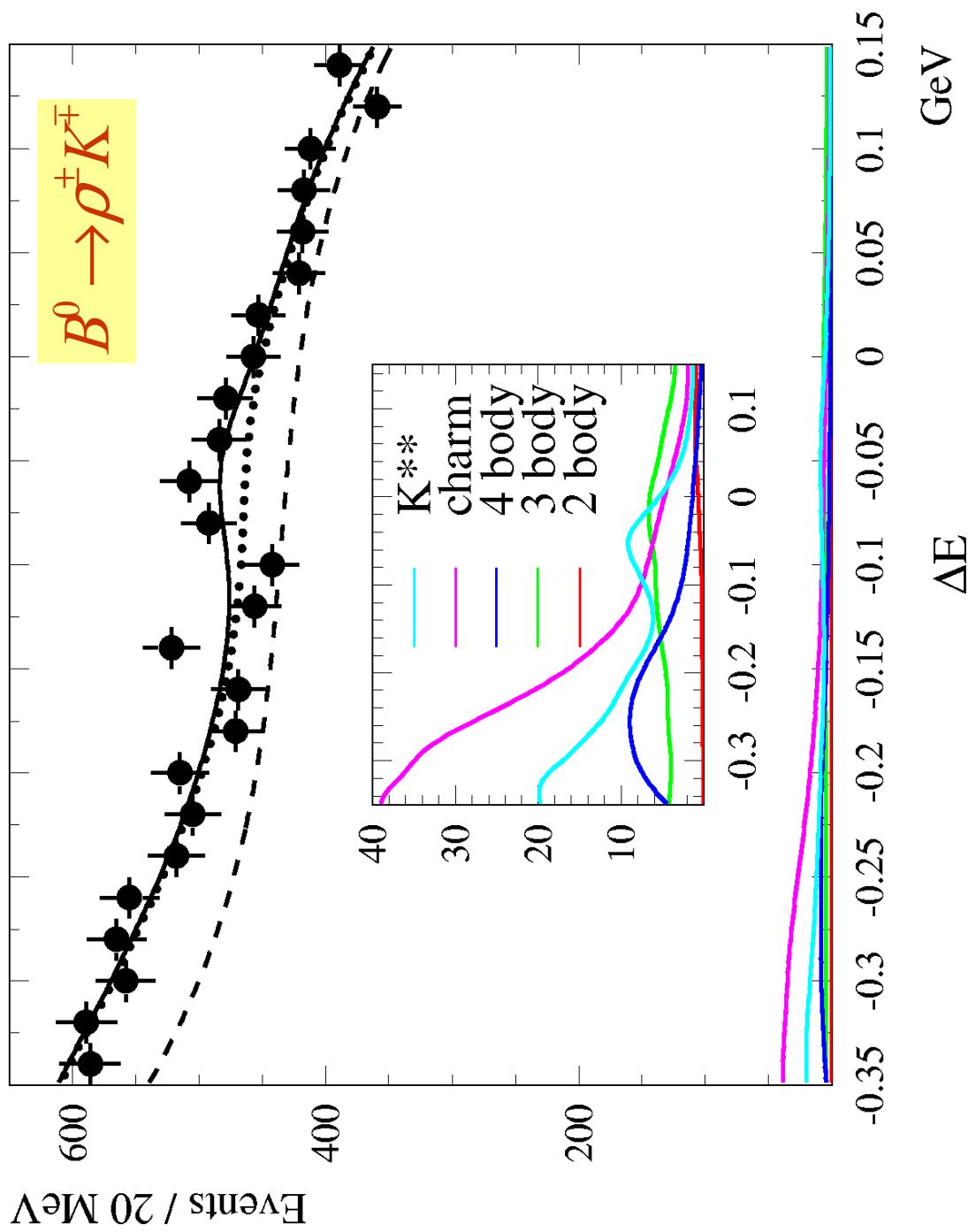
Measurement of the inclusive $b \rightarrow$ charm rate

repeat our full likelihood fit with full B-bkg model



Measurement of the inclusive $b \rightarrow$ charm rate

repeat our full likelihood fit with full B-bkg model



Measurement of the inclusive $b\rightarrow\text{charm}$ rate

- float $b\rightarrow\text{charm}$ contribution on the top of the fixed $b\rightarrow\text{charmless}$ and floated continuum:

Fit parameter	Mode	MC expectation	Fit result
2	$B^\pm \rightarrow \text{charm}(\rho^\pm K^\mp)$	261	92.1 ± 96.0
3	$B^0/\bar{B}^0 \rightarrow \text{charm}(\rho^\pm K^\mp)$	64	207.8 ± 107.2
4	$B^\pm \rightarrow \text{charm}(\rho^\pm \pi^\mp)$	960	648.1 ± 145.3
5	$B^0/\bar{B}^0 \rightarrow \text{charm}(\rho^\pm \pi^\mp)$	511	595.1 ± 144.5

Table 8: Fit result when floating the four charm B -background contributions.

- consistent with MC predictions within errors - keep MC predictions for the central value
- becomes even more important issue for Dalitz analysis (where $b\rightarrow\text{charm}$ is dominant B -background! See Sandrine's talk)

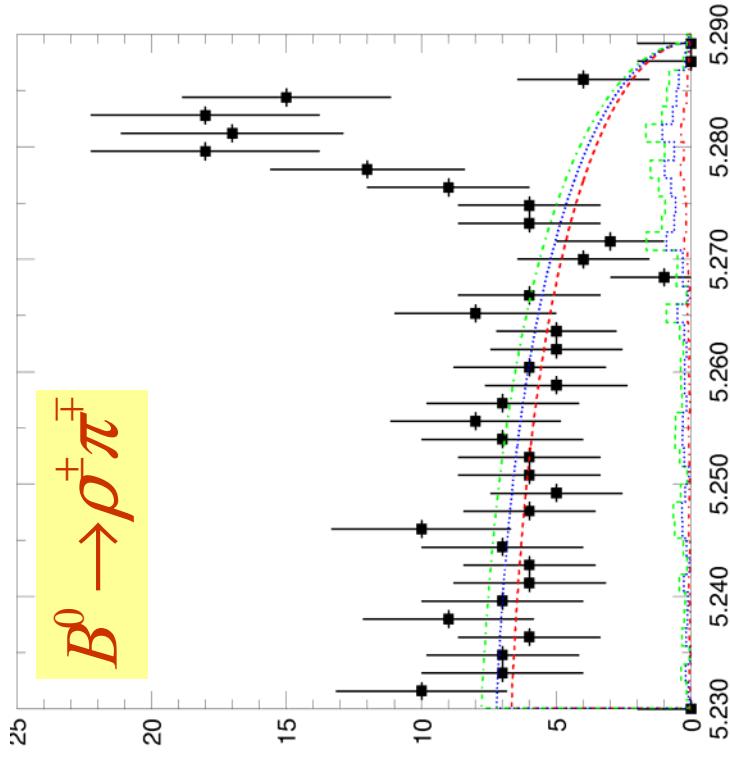
Cut&Count measurement of

$$Br(B^0 \rightarrow \rho^\pm \pi^\mp), Br(B^0 \rightarrow \rho^\pm K^\mp)$$

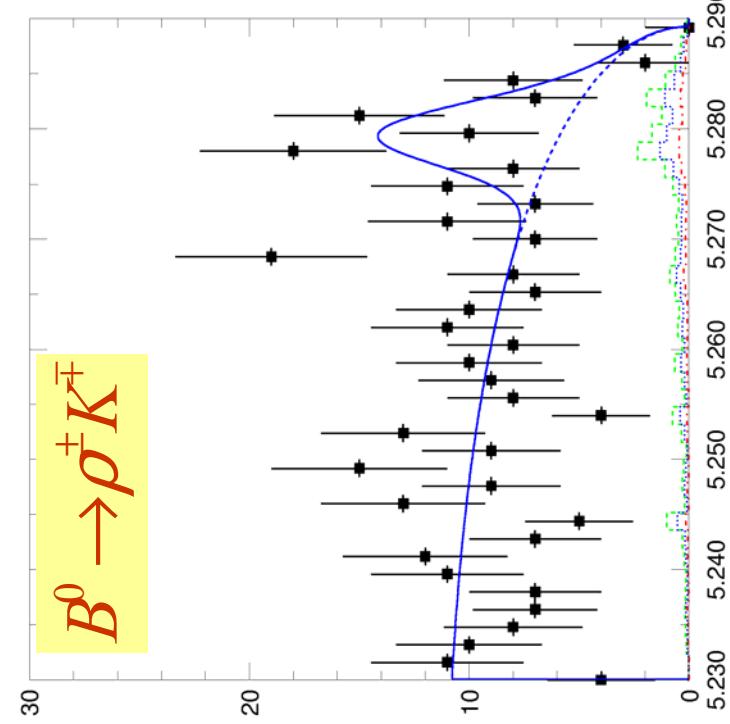
- 1D m_{ES} Cut&Count with tighter cuts on:
 $0.6 < m_p < 1.0 \text{ GeV}, h_p > -0.8, -0.12 < \Delta E < 0.07$
- simple event shape variables instead of NN for continuum suppression:
 $|\cos\Theta_T| < 0.9,$
 $L_2 = 3P_2 - P_0 < -1.0(-0.5)$
- PID-based selectors are used for Pi-K separation
- additional continuum suppression is achieved by using tagged events only(selection efficiencies ~4%)

Cut&Count measurement of

$$Br(B^0 \rightarrow \rho^\pm \pi^\mp), Br(B^0 \rightarrow \rho^\pm K^\mp)$$



$B^0 \rightarrow \rho^+ \pi^-$

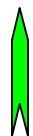


$B^0 \rightarrow \rho^+ K^-$

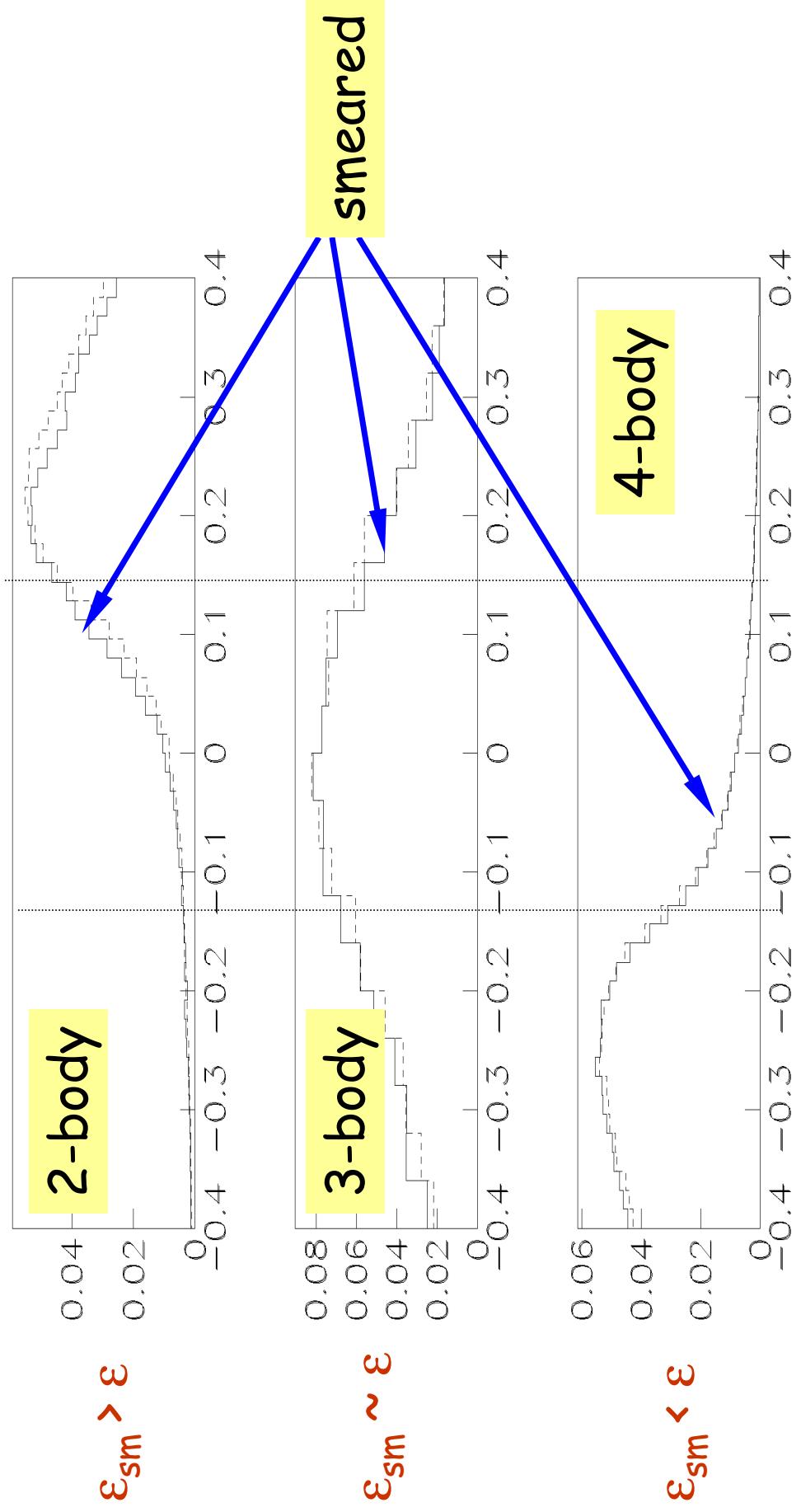
$$Br(B^0 \rightarrow \rho^+ \pi^-) = (2.1 \pm 0.25 \pm 0.39) \cdot 10^{-6}$$

$$Br(B^0 \rightarrow \rho^+ K^-) = (0.8^{+0.26}_{-0.23} \pm 0.13) \cdot 10^{-6}$$

consistent with full fit results



Switch to smeared MC sample for B-bkg with energetic PiO's (when B-reco is not enough...)



→ quantitatively, the impact on fit values is small, but
helps to improve overall fit stability

Updated B-reco

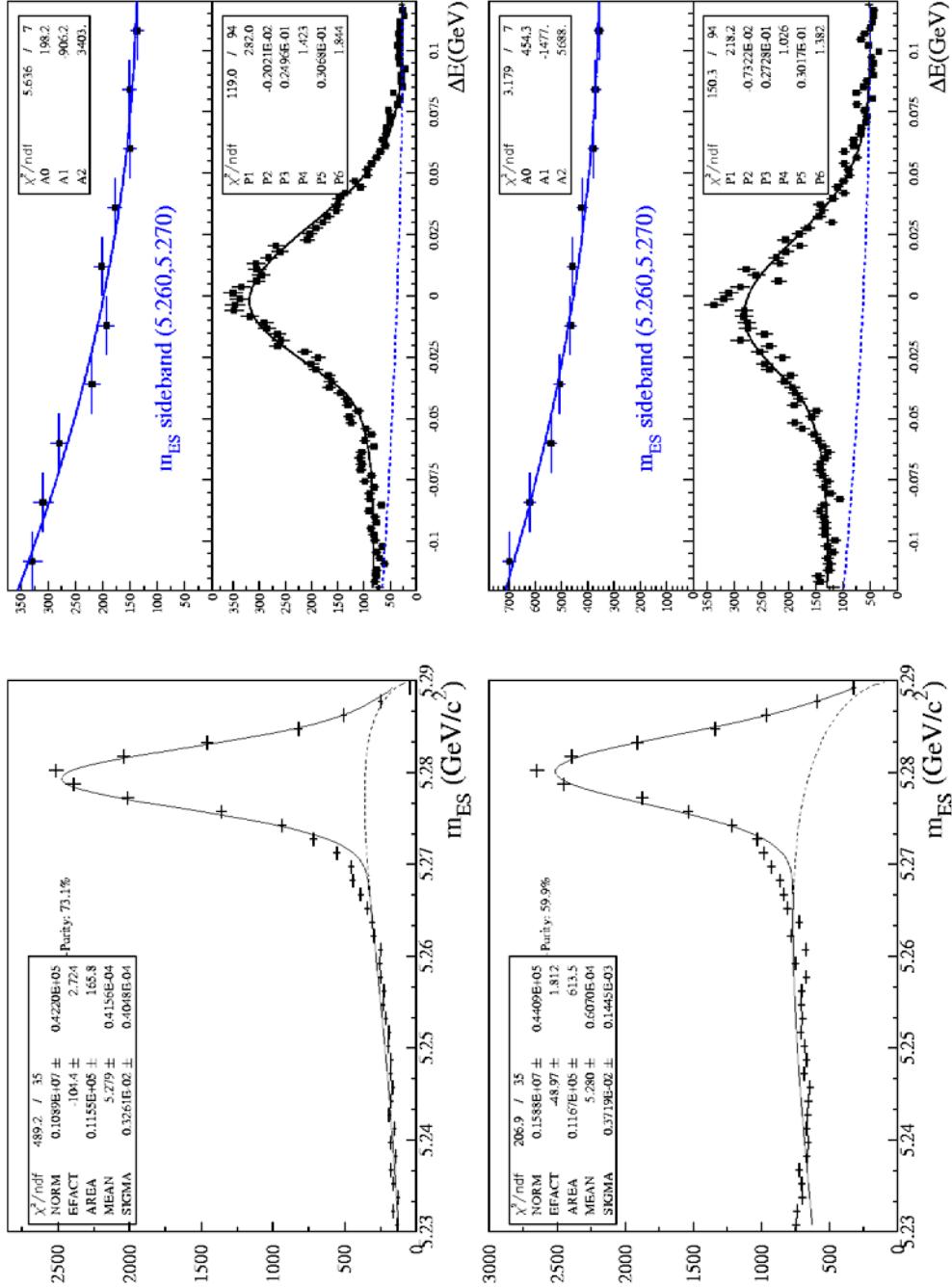


Figure 9: *Upper half:* m_{ES} Distribution for $B^0 \rightarrow D^- \rho^+$ candidates in generic B MC (left); the ΔE distribution for MC candidates with $5.26 \text{ GeV}/c^2 < m_{ES} < 5.27 \text{ GeV}/c^2$ (upper right), $|m_{ES} - 5.279| < 0.006 \text{ GeV}/c^2$ (lower right). *Lower half:* Distribution of the variable m_{ES} for $B^0 \rightarrow D^- \rho^+$ candidates in data (left); the ΔE distribution for candidates with $5.26 \text{ GeV}/c^2 < m_{ES} < 5.27 \text{ GeV}/c^2$ (upper right), $|m_{ES} - 5.279| < 0.006 \text{ GeV}/c^2$ (lower right).

Updated B-reco

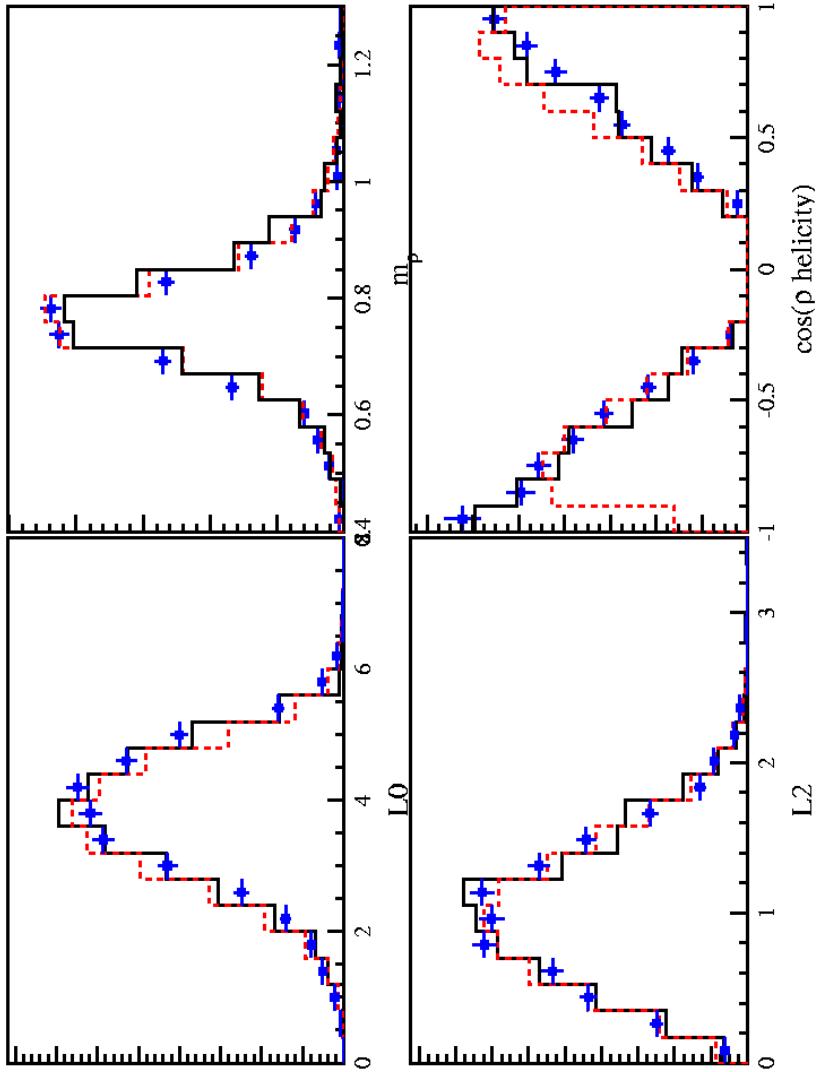


Figure 10: Distributions of MVA variable PDFs measured for reconstructed $B^0 \rightarrow D^- \rho^+$ data(dots) and MC(solid line) and for truth matched $B^0 \rightarrow \rho^+ \pi^-$ MC(dash line)

Conclusion

- as a result of all the changes fit to data became very stable - converge even without M_{ES}
- toys and major checks are OK so far
- compared to ICHEP, we see changes in $N(Rhok)$, c and dC - the difference is understood
- fit is frozen, systematics and cross-checks are being Done for CP and BRs measurements
- BAD and PRL will be out ASAP